International Journal of Environment, Ecology, Family and Urban Studies (IJEEFUS)
ISSN(P): 2250-0065; ISSN(E): 2321-0109
Vol. 7, Issue 3, Jun 2017, 11-20
© TJPRC Pvt. Ltd.

TRANS STELLAR
• Journal Publications • Research Consultancy

EFFECT OF UREASE AND DEHYDROGENASE ACTIVITY IN SOILS OF *SIMAROUBA GLAUCA* AND *CALOPHYLLUM INOPHYLLUM* PLANTATIONS ON DECOMPOSITION OF LEAF LITTER AND NUTRIENT DYNAMICS

PRASANNA KUMAR M, GIRIPRASAD M. H, GOPIKA M. H, NAGARAJU & HATTAPPA S

University of Agricultural Sciences, GKVK, Bangalore, Karnataka, India

ABSTRACT

Field experiment, "Studies on decomposition of leaf litter and nutrient dynamics of Simarouba glauca and Calophyllum inophyllum agro-forestry tree species" was conducted at GKVK, Bengaluru and ARS Hassan during winter and summer 2014-15. The experiment comprising of sixteen treatments consisting of two tree species, two depths, two locations in two seasons, laid out in a factorial RCBD with three replications. The leaf litter production quantified for two seasons during the winter and summer (November to April 2015) in Simarouba and Calophyllum at two locations revealed that the highest leaf litter fall was recorded during winter in Simarouba (24.33 kg tree^{-1} month^{-1}) and the lowest in Calophyllum (2.7 kg tree^{-1} month^{-1}) during summer. The urease activity was recorded significantly highest in Simarouba plantation (102.09g NH_4^{-1} g^{-1} soil 2hr^{-1}) during winter, compared to Calophyllum at 90 days after leaf litter decomposition. The highest urease activity was recorded at Bangalore plantation compared to Hassan plantation. The dehydrogenase activity at 90 days after leaf litter decomposition was significantly higher at 5 cm depth in Simarouba plantation (112.6 g NH_4^{-1} g^{-1} soil 2hr^{-1}) during winter, compared to Calophyllum. The highest dehydrogenase activity was recorded at Bangalore plantation compared to Hassan plantation. The Simarouba tree species litter had a higher initial nutrient content and released its nutrients faster with a higher proportion than the Calophyllum tree, thus significantly higher soil fertility was obtained in Simarouba agro-forestry system.

***KEYWORDS:** Simarouba, Calophyllum, Urease Activity, Dehydrogenase Activity, Leaf Litter & Nutrient Dynamics*

Received: Mar 27, 2017; **Accepted:** Apr 17, 2017; **Published:** May 16, 2017; **Paper Id.:** IJEEFUSJUN20172

INTRODUCTION

The importance of litter production in forest ecosystems has long been recognized, because most of the organic matter produced by plants through photosynthesis returns to soil as litter. Litter fall may be a seasonal or a continuous process and represents one of the most important pathways for the transfer of energy and material. These two processes are determined to a large extent by the structural and functional features of the ecosystems. This litter fall is a key process in determining the nutrient cycling of forest ecosystems. The magnitude of the leaf litter fall regulates the rate of soil respiration and soil organic carbon content, thus maintaining soil fertility. The decomposition is regulated by soil organisms, environmental conditions and the chemical nature of the litter. The decay of organic matter returned to the soil through litter fall is an important source of inorganic ions for plant uptake, and the nutrients is released from decaying organic matter by physical and biological processes (Baker and Attiwill, 1985). The decomposition of leaf litter plays an important role in maintaining soil fertility in terms of nutrient cycling and formation of soil organic matter (Guendehou *et al.* 2014). In this context, Simarouba glauca DC. Belongs to the family Simaroubaceae. It is a multipurpose tree that can grow well under a wide range of hostile ecological conditions. It was first introduced by the National Bureau of Plant Genetic Resources in the

research station at Amravati in Maharashtra in 1966, and later on to the University of Agricultural Sciences, Bengaluru in 1986. In India, it is cultivated in Orissa, Maharashtra, Gujarat, Rajasthan, Andhra Pradesh, Karnataka, Tamilnadu, West Bengal and Orissa. S. glauca tree has an ability to grow well even in marginal waste lands or dry lands, with degraded soil. With well-developed root system and with evergreen dense canopy it efficiently checks soil erosion, recharges ground water, supports soil microbial activities and improves soil fertility. The addition of biomass to waste lands at the rate of 10-15 tonnes ha-1year^{-1} helps in the improvement of physical and biological properties of soils (Shyamsundar and Shantha, 2008). The other important species Calophyllum inophyllum L. belonging to the family Clusiaceae/Guttiferae is a large and medium sized evergreen sub-maritime tree, growing to a height of 20 meters. The plant is named for its beautiful fibrous leaves. It is native of India, indigenous to South East Asia, widely distributed throughout the tropics including Hawaiian. It grows along the coastal area and adjacent lowland forests, although occasionally occurs inland, at higher elevations and grows in areas with annual rainfall ranging from about 1000 to 5000mm (Friday and Okano, 2004). It is a useful tree for coastal shelterbelts, windbreaks and strand reforestation, because it grows well despite the wind, salt spray, drought, and occasional flooding common to beach environments. It has a shallow root system, prefers sandy or porous soils and tolerates occasional inundation. The tree grows best in direct sunlight, but grows slowly.

MATERIAL AND METHODS

Field investigations were carried out during 2014 November, to assess the "Studies on decomposition of leaf litter and nutrient dynamics of *Simarouba glauca* and *Calophyllum inophyllum* Agro-forestry tree species" in Eastern Dry Zone at the All India Coordinated Research Project (AICRP) Agro-forestry UAS, GKVK, Bengaluru and Transition Zone at biofuel park, Hassan during the year 2014-15. The leaf litter biomass production was determined in Simarouba (*Simarouba glauca* DC.) and Calophyllum (*Calophyllum inophyllum* L.) plantations at two selected locations in Eastern Dry Zone (Bengaluru) and Transition Zone (Hassan). The seasonal variation of leaf litter fall quantification was out by installing litter fall collection traps. The nylon mesh bags filled with leaf litter collected from these plantations were buried in soil at 5 cm and 10 cm depths. Then, the samples collected were analyzed for different parameters. The experiment had been laid out as per Factorial Randomized Complete Block Design (FRCBD), by considering 2 tree species (Simarouba and Calophyllum) and 2 depths (5 cm and 10 cm) in 2 locations (Bengaluru and Hassan) at 2 seasons (winter and summer), with 3 replications. The soil of the experimental site was red sandy loam with a gravelly texture in All India Coordinated Research Project (AICRP), Bengaluru. Composite samples were drawn from the experimental site. Soil samples were collected air dried, powdered, sieved and analyzed for further physical and chemical analysis at before and end of the season. The soil of the experimental site was sandy loam with a gravelly texture in Bio-fuel Park Hassan. Composite samples were drawn from the experimental site. Soil samples were collected air dried, powdered, sieved and analyzed for further physical and chemical analysis at before and end of the season. Initial chemical characteristics of Simarouba and Calophyllum leaf litter revealed that, the Simarouba leaf has 1.28 percent of N, 0.06 percent of P, 0.53 percent of K, 0.34 percent of S, 182.13 ($\mu g\ g^{-1}$) of NH_3-N and 55.49 ($\mu g\ g^{-1}$) of NO_3-N. Whereas, in Calophyllum leaf contains 0.73 percent of N, 0.048 percent of P, 0.85 percent of K, 0.28 percent of S, 130.14 ($\mu g\ g^{-1}$) of NH_3-N and 35.08 ($\mu g\ g^{-1}$) of NO_3-N, respectively at both the sites.

RESULTS AND DISCUSSIONS

The leaf litter production quantified for two seasons, winter and summer season (November to April 2015) in the two locations, one at eastern dry zone located at All India Coordinated Research Project (AICRP), agro-forestry, UAS,

GKVK, Bangalore and another one in the transition zone situated in biofuel park, Hassan. A unimodal peak in total leaf litter production with maximum was recorded during winter in January–February at both the locations (Table 1 & 2).

On a monthly basis, the mean leaf litter production in Simarouba and Calophyllum was recorded higher in the month of February followed by January, and the least litter fall was recorded in the month of November at eastern dry zone. In the transitional zone also the same pattern of litter fall was recorded in both the tree species. This is due to the closed canopy of trees, which helped in moisture retention in dry regions for a longer period and could cause late shedding of leaves. Table1 and 2 clearly indicates that, on an average, leaf litter fall was more in winter season compared to summer season. The same trend was recorded by Gonza *et al*., (2010), wherein, they reported that litter fall in the floodplain level (mean = 563 g m^{-2} y^{-1}) was slightly higher than that found in other riparian forests in the Mediterranean and Iberian rivers (mean = 551 g m^{-2} y^{-1}), but had a low proportion of leaves (57 %) compared with the worldwide average of 70 per cent in deciduous riparian forests. The production of litter depends primarily on the site productivity, but the environment and other factors such as temperature, water and mineral nutrient availability which limit litter production (Jorgensen *et al.,* 1975), which leads to moisture stress and hence leaf sheaths. Another possible reason could be due to the fact that plants respire more in drier season compared to winter and rainy seasons. This lead to more loss of water due to high transpiration and respiration rates, causing leaf shedding to conserve water within its body. Similar observations were reported by Hudds, 1971 and Facelli and Pickett, 1991.

Urease Activity

The urease is an enzyme, which brings about hydrolysis of urea. In the present study, there was a significant increase in urease activity in 30, 60 and 90th days after leaf litter decomposition. The highest urease activity in soils was recorded in Simarouba plantation during the winter season at Bangalore location; however the lowest was recorded in Calophyllum planting during summer season. Similarly, the highest urease activity was recorded in Simarouba plantation during the winter season at Hassan location followed by summer season in Calophyllum soil (Table 3, 4 & 5). A similar trend was recorded by Makoi and Ndakidemi (2008), who inferred that the enzyme is involved in the hydrolysis of urea into CO_2 and NH_3 and consequently increase in soil pH and N losses as NH_3 through volatilization. Due to the role of urease activity, focus has been placed on urease, in order to evaluate N supply to plants. However, urease activity has been reported as being very inefficient due to large N losses to the atmosphere, by volatilization, mediated by these enzymes. Waring and Schlesinger (1985) observed that, microbial activity increases exponentially with increasing temperature and as a result, high temperature results in rapid decomposition and higher accumulation of organic matter. Higher urease activity during winter is attributed to higher organic matter accumulation, and in terms of higher microbial activity in addition to more moisture content in soils. Further, lower urease activity during summer was attributed to low soil moisture and slow rate of decomposition, in terms of lower microbial activity during summer.

Dehydrogenase Activity

Significantly higher dehydrogenase activity in Soils was recorded in Simarouba plantation during winter season in Bangalore location at 30, 60 and 90th days after leaf litter decomposition, followed in Calophyllum plantation during summer. Similarly the highest dehydrogenase activity was recorded in Simarouba plantation during winter at Hassan location 30, 60 and 90th days, followed by summer in Calophyllum soil (Table 6,7 & 8). Similar observations were reported by gores *et al.* (1998), where they reported the higher inputs of organic residues during autumn (leaf-shedding season) in the forest ecosystem that could contribute to the seasonal increase in DHA. The litter fall inputs favor the overall

soil oxidative activity; as the litter fall undergoes decomposition, smaller and simpler organic molecules are leached down from the litter layer to the surface soil horizon as water-soluble organic matter, thus providing a labile organic substrate for soil microorganisms. Yuan and Yue (2012) stated the highest DHA in winter season, which could be due to increased bacterial and fungal population. Addition of leaf litter favors the population of fungi and bacteria and hence, dehydrogenase activity was higher.

CONCLUSIONS

The outcome of the experiment showed that, the rate of decomposition and also leaf litter production was significantly higher in Simarouba compared to Calophyllum. The microbial activities were recorded highest during winter season in Simarouba plantation, compared to Calophyllum plantation during summer season. The seasonal changes of nutrient status in soil were recorded significantly higher during winter. This study suggests that both tree species are increasing litter production and nutrient returns, and are helpful to restore soil fertility in agro-forestry system.

REFERENCES

1. *BAKER, T. G. AND ATTIWILL, P. M., 1985, Loss of organic matter and elements from decomposing litter of Eucalyptus obliqua L. Herit and Pinus radiata D. Don. Australian Forest Research,* ***15****: 309-319.*
2. *FACELLI, J. M. AND PICKETT, S. T. A., 1991, Plant litter: Its dynamics and effects on plant community structure. Bot. Rev.,* ***57:*** *1-32.*
3. *FRIDAY AND OKANO, 2004, Biology, agroforestry and medicinal value of calophyllum inophyllum L. (clusiacea): a review. International Journal of Natural Products Research.,* ***1****(2): 24-33.*
4. *GONZA, E., MULLER, E, GALLARDO, B, COMI´N, F. A. AND GONZALEZ, S. M., 2010, Factors controlling litter production in a large Mediterranean river floodplain forest. Canadian Journal of Forest Research,* ***40****: 1698–1709.*
5. *GORRES, J. H., DICHIARO, M. J., LYONS, J. B., AND AMADOR, J. A., 1998, Spatial and temporal patterns of soil biological activity in a forest and an old field. Soil BiolBiochem.,* ***30****: 219–230.*
6. *GUENDEHOU, G. H. S., LISKI, J., TUOMI, M., MOUDACHIROU, M., SINSIN, B. AND MAKIPAA, R., 2014, Decomposition and changes in chemical composition of leaf litter of five dominant tree species in a West African tropical forest. Tropical Ecology,* ***55****: 207-220.*
7. *HUDDS, R. M., 1971, Annual tree litter production by successional forest stands, Juneau, Alaska. Ecology.,* ***52:*** *881-884.*
8. *JORGENSEN, J. R., WELLS, C. G. AND METZ, L. J., (1975), The nutrient cycle. Key to continuous forest production, Journal of Forestry.,* ***73(7):*** *pp 400-403.*
9. *MAKOI AND NDAKIDEMI, P. A., 2008, Selected soil enzymes; Examples of their potential roles in the ecosystem. Afri. J. Biotech., 7 (3): 181-191.*
10. *SHYAMSUNDAR JOSHI AND SHANTHA JOSHI, 2008, Simarouba glauca DC. Univ. Agril.Sci., GKVK Bangalore 65 India.*
11. *WARING, R. H. AND SCHLESINGER, W. H., 1985, Nutrient cycling through forests. In: Forest Ecosystems. Concepts and Management. Academic Press, Orlando, FL., 121-156.*
12. *YUAN, B. AND YUE, D., 2012, Soil microbial and enzymatic activities across a chronosequence of Chinese pine plantation development on the loess plateau of china. Pedosphere,* ***22:*** *pp. 1-12.*

APPENDICES

Table 6: Leaf Litter Fall (Kg tT

Table 1: Leaf Litter Fall (Kg $Tree^{-1}$ $Month^{-1}$) in Different Months at Bengaluru Plantations

Trees	November		December		January		February		March		April	
	S	C	S	C	S	C	S	C	S	C	S	C
1	3.95	0.51	4.50	0.69	6.75	0.94	7.58	0.86	6.75	0.95	6.45	0.78
2	4.75	0.62	5.10	0.81	7.35	0.85	8.25	0.75	7.40	0.80	7.23	0.81
3	4.35	0.65	4.90	0.73	7.50	0.91	8.50	0.89	7.15	1.00	6.57	0.82
Sum	13.05	1.78	14.5	2.23	21.6	2.70	24.33	2.50	21.30	2.70	20.25	2.41
Mean	4.35	0.59	4.83	0.74	7.20	0.90	8.11	0.83	7.10	0.92	6.75	0.80
SD	0.4	0.07	0.30	0.06	0.39	0.04	0.47	0.07	0.32	0.10	0.42	0.02
CV	9.19	12.4	6.32	8.21	5.51	5.09	5.86	8.84	4.61	11.3	6.22	2.59

Table 2: Leaf Litter Fall (Kg $Tree^{-1}$ $Month^{-1}$) in Different Months at Hassan Plantations

Trees	November		December		January		February		March		April	
	S	C	S	C	S	C	S	C	S	C	S	C
1	4.50	0.71	5.58	0.81	7.85	0.86	8.85	0.75	6.10	0.85	6.03	0.73
2	5.10	0.64	6.10	0.74	6.35	0.89	6.75	0.90	5.50	0.79	5.89	0.69
3	4.85	0.61	5.94	0.76	7.46	0.95	8.15	0.86	5.94	0.96	5.95	0.81
Sum	14.45	1.96	17.62	2.31	21.66	2.70	23.75	2.51	17.54	2.60	17.87	2.23
Mean	4.82	0.65	5.87	0.77	7.22	0.90	7.92	0.84	5.85	0.87	5.96	0.74
SD	0.30	0.05	0.26	0.03	0.77	0.04	1.06	0.07	0.31	0.08	0.07	0.06
CV	6.25	7.85	4.53	4.68	10.7	5.09	13.5	9.28	5.31	9.94	1.18	8.22

S=*Simarouba glauca*; C= *Calophyllum inophyllum*

Table 8: Urease Activity (∝g NHTaTTa

Table 3: Urease Activity (∝g NH $^{-1}$ g^{-1} Soil 2hr^{-1}) in Soil at 30 Days after Leaf Litter Decomposition as Influenced by Soil Depth, Seasons and Locations of Trees under Agro Forestry System

Details	L_1			L_2			Pooled		
	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean
S_1D_1	88.41	75.09	81.75	84.05	73.67	78.86	86.23	74.38	80.31
S_1D_2	86.33	74.05	80.19	83.03	72.84	77.94	84.68	73.45	79.06
Mean	87.37	74.57	80.97	83.54	73.26	78.4	85.46	73.91	79.68
S_2D_1	77.91	68.49	73.2	74.69	67.37	71.03	76.3	67.93	72.12
S_2 D_2	76.45	66.59	71.52	72.64	65.43	69.04	74.55	66.01	70.28
Mean	77.18	67.54	72.36	73.67	66.4	70.03	75.42	66.97	71.2
D_1	83.16	71.79	77.48	79.37	70.52	74.95	81.27	71.16	76.21
D_2	81.39	70.32	75.86	77.84	69.135	73.49	79.61	69.73	74.67
Mean	82.28	71.06	76.67	78.6	69.83	74.22	80.44	70.44	75.44

Comparison	S	T	D	L	S×T	S×D	S×L	T×D	T×L	D×L	S×T×D	S×T×L	S×D×L	T×D×L	S×T×D×L
SEm±	0.67	0.67	0.67	0.67	0.95	0.95	0.95	0.95	0.95	0.95	1.35	0.05	1.35	1.35	1.91
CD at 5 %	1.94	1.94	1.94	1.94	2.75	2.75	2.75	2.75	2.75	2.75	3.89	0.15	3.89	3.89	5.50

Note: **S_1**: Winter season, **S_2**: Summer season, **D_1**: Depth at 5cm, **D2**: Depth at 10cm, **L_1**: Agro-forestry Bengaluru, **L_2**: Bio-fuel park Hassan, **T_1**:*Simarouba glauca,* **T_2**:*Calophyllum inophyllum*

Table 3: Urease Activity (∝g

Table 4: Urease Activity (∝g NH $^{-1}$g^{-1} Soil 2hr^{-1}) in Soil at 60 Days after Leaf Litter Decomposition as Influenced by Soil Depth, Seasons and Locations of Trees under Agro Forestry System

Details	L_1			L_2			Pooled		
	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean
S_1D_1	98.34	80.82	86.73	96.71	79.61	88.16	96.71	79.61	88.16
S_1D_2	95.61	78.09	84.14	94.16	76.84	85.5	94.16	76.84	85.5
Mean	96.98	79.46	85.44	95.43	78.22	86.83	95.43	78.22	86.83
S_2D_1	88.15	74.1	79.26	86.95	73.43	80.19	86.95	73.43	80.19
S_2 D_2	86.08	72.5	76.25	84.28	71.27	77.77	84.28	71.27	77.77
Mean	87.12	73.3	77.75	85.61	72.35	78.98	85.61	72.35	78.98
D_1	93.25	77.46	82.99	91.83	76.52	84.17	91.83	76.52	84.17
D_2	90.85	75.3	80.2	89.22	74.05	81.63	89.22	74.05	81.63
Mean	92.05	76.38	81.59	90.52	75.28	82.9	90.52	75.28	82.9

Comparison	S	T	D	L	S×T	S×D	S×L	T×D	T×L	D×L	S×T×D	S×T×L	S×D×L	T×D×L	S×T×D×L
SEm±	0.74	0.74	0.74	0.74	1.04	1.04	1.04	1.04	1.04	1.04	1.47	0.06	1.47	1.47	2.09
CD at 5 %	2.13	2.13	2.13	2.13	3.01	3.01	3.01	3.01	3.01	3.01	4.25	0.18	4.25	4.25	6.01

Note: $\mathbf{S_1}$: Winter season, $\mathbf{S_2}$: Summer season, $\mathbf{D_1}$: Depth at 5cm, **D2**: Depth at 10cm, $\mathbf{L_1}$:Agro-forestry Bengaluru, $\mathbf{L_2}$: Bio-fuel park Hassan, $\mathbf{T_1}$:*Simarouba glauca,* $\mathbf{T_2}$:*Calophyllum inophyllum*

Table 4: Urease Activity (∝g NH $^{-1}$

Table 5: Urease Activity (∝g NH $^{-1}$g^{-1} Soil 2hr^{-1}) in Soil at 90 Days after Leaf Litter Decomposition as Influenced by Soil Depth, Seasons and Locations of Trees under Agro Forestry System

Details	L_1			L_2			Pooled		
	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean
S_1D_1	108.16	91.65	99.91	105.04	88.83	96.94	106.60	90.24	98.42
S_1D_2	106.84	89.83	98.34	102.74	86.42	94.58	104.79	88.13	96.46
Mean	107.5	90.74	99.12	103.89	87.63	95.76	105.70	89.18	97.44
S_2D_1	100.52	87.99	94.26	97.63	85.6	91.62	99.08	86.8	92.94
S_2 D_2	98.87	85.81	92.34	96.91	83.46	90.19	97.89	84.64	91.26
Mean	99.7	86.9	93.3	97.27	84.53	90.9	98.48	85.72	92.1
D_1	104.34	89.82	97.08	101.34	87.22	94.28	102.84	88.52	95.68
D_2	102.86	87.82	95.34	99.83	84.94	92.38	101.34	86.38	93.86
Mean	103.6	88.82	96.21	100.58	86.08	93.33	102.09	87.45	94.77

Comparison	S	T	D	L	S×T	S×D	S×L	T×D	T×L	D×L	S×T×D	S×T×L	S×D×L	T×D×L	S×T×D×L
SEm±	0.33	0.33	0.33	0.33	0.47	0.47	0.47	0.47	0.47	0.47	0.67	0.09	0.67	0.67	0.94
CD at 5 %	0.96	0.96	0.96	0.96	1.36	1.36	1.36	1.36	1.36	1.36	1.92	0.25	1.92	1.92	2.71

Note: $\mathbf{S_1}$: Winter season, $\mathbf{S_2}$: Summer season, $\mathbf{D_1}$: Depth at 5cm, **D2**: Depth at 10cm, $\mathbf{L_1}$:Agro-forestry Bengaluru, $\mathbf{L_2}$: Bio-fuel park Hassan, $\mathbf{T_1}$:*Simarouba glauca,* $\mathbf{T_2}$:*Calophyllum inophyllum*

Table 8: Urease Activity (∝g NH $^{-}$t

Table 6: Dehydrogenase Activity (∝g TPF g^{-1} Soil Day^{-1}) in Soil at 30 Days after Leaf Litter Decomposition as Influenced by Soil Depth, Seasons and Locations of Trees under Agro Forestry System

Details	L_1			L_2			Pooled		
	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean
S_1D_1	95.07	80.42	87.75	91.72	78.97	85.35	93.4	79.7	86.55
S_1D_2	92.64	79.68	86.16	89.89	77.91	83.9	91.27	78.8	85.03
Mean	93.86	80.05	86.95	90.81	78.44	84.62	92.33	79.25	85.79
S_2D_1	82.25	70.49	76.37	81.35	68.77	75.06	81.8	69.63	75.72
$S_2 D_2$	80.12	68.99	74.56	79.74	66.73	73.24	79.93	67.86	73.9
Mean	81.19	69.74	75.46	80.55	67.75	74.15	80.87	68.75	74.81
D_1	88.66	75.46	82.06	86.54	73.87	80.2	87.6	74.66	81.13
D_2	86.38	74.34	80.36	84.82	72.32	78.57	85.6	73.33	79.46
Mean	87.52	74.9	81.21	85.68	73.1	79.39	86.6	74	80.3

Comparison	S	T	D	L	S×T	S×D	S×L	T×D	T×L	D×L	S×T×D	S×T×L	S×D×L	T×D×L	S×T×D×L
SEm±	0.85	0.85	0.85	0.85	1.20	1.20	1.20	1.20	1.20	1.20	1.70	0.35	1.70	1.70	2.40
CD at 5 %	2.45	2.45	2.45	2.45	3.46	3.46	3.46	3.46	3.46	3.46	4.90	1.01	4.90	4.90	6.93

Note: $\mathbf{S_1}$: Winter season, $\mathbf{S_2}$: Summer season, $\mathbf{D_1}$: Depth at 5cm, **D2**: Depth at 10cm, $\mathbf{L_1}$:Agro-forestry Bengaluru, $\mathbf{L_2}$: Bio-fuel park Hassan, $\mathbf{T_1}$:*Simarouba glauca*, $\mathbf{T_2}$:*Calophyllum inophyllum*

Dehydrogenase Activity (∝gTPF g^{-1} s

Table 7: Dehydrogenase Activity (∝g TPF g^{-1} Soil Day^{-1}) in Soil at 60 Days after Leaf Litter Decomposition as Influenced by Soil Depth, Seasons and Locations of Trees under Agro Forestry System

Details	L_1			L_2			Pooled		
	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean
S_1D_1	106	93.16	99.58	103.4	89.06	96.23	104.7	91.11	97.91
S_1D_2	104.27	90.76	97.52	101.7	87.12	94.41	102.99	88.94	95.96
Mean	105.14	91.96	98.55	102.55	88.09	95.32	103.84	90.03	96.93
S_2D_1	98.15	88.77	93.46	96.75	84.43	90.59	97.45	86.6	92.03
$S_2 D_2$	95.41	83.5	89.46	93.47	79.7	86.59	94.44	81.6	88.02
Mean	96.78	86.14	91.46	95.11	82.07	88.59	95.95	84.1	90.02
D_1	102.08	90.97	96.52	100.08	86.75	93.41	101.08	88.86	94.97
D_2	99.84	87.13	93.49	97.59	83.41	90.5	98.71	85.27	91.99
Mean	100.96	89.05	95	98.83	85.08	91.95	99.89	87.06	93.48

Comparison	S	T	D	L	S×T	S×D	S×L	T×D	T×L	D×L	S×T×D	S×T×L	S×D×L	T×D×L	S×T×D×L
SEm±	0.58	0.58	0.58	0.58	0.82	0.82	0.82	0.82	0.82	0.82	1.17	0.27	1.17	1.17	1.65
CD at 5 %	1.68	1.68	1.68	1.68	2.38	2.38	2.38	2.38	2.38	2.38	3.36	0.77	3.36	3.36	4.75

Note: $\mathbf{S_1}$: Winter season, $\mathbf{S_2}$: Summer season, $\mathbf{D_1}$: Depth at 5cm, **D2**: Depth at 10cm, $\mathbf{L_1}$:Agro-forestry Bengaluru, $\mathbf{L_2}$: Bio-fuel park Hassan, $\mathbf{T_1}$:*Simarouba glauca*, $\mathbf{T_2}$:*Calophyllum inophyllum*

Soil Day^{-1}) in Soil at 30 Days afT

Table 8: Dehydrogenase Activity (∝g TPF g^{-1} Soil Day^{-1}) in Soil at 90 Days after Leaf Litter Decomposition as Influenced by Soil Depth, Seasons and Locations of Trees under Agro Forestry System

Details	L_1			L_2			Pooled		
	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean
S_1D_1	120.16	99.99	110.08	116.71	97.73	107.22	118.44	98.86	108.65
S_1D_2	118.5	96.83	107.67	113.08	93.56	103.32	115.79	95.2	105.49
Mean	119.33	98.41	108.87	114.9	95.65	105.27	117.11	97.03	107.07
S_2D_1	111.85	95.99	103.92	107.3	91.93	99.62	109.58	93.96	101.77
S_2D_2	109.54	93.26	101.4	103.65	89.79	96.72	106.6	91.53	99.06
Mean	110.7	94.63	102.66	105.48	90.86	98.17	108.09	92.74	100.41
D_1	116.01	97.99	107	112.01	94.83	103.42	114.01	96.41	105.21
D_2	114.02	95.05	104.53	108.37	91.68	100.02	111.19	93.36	102.28
Mean	115.01	96.52	105.77	110.19	93.25	101.72	112.6	94.89	103.74

Comparison	S	T	D	L	S×T	S×D	S×L	T×D	T×L	D×L	S×T×D	S×T×L	S×D×L	T×D×L	S×T×D×L
SEm±	0.74	0.74	0.74	0.74	1.05	1.05	1.05	1.05	1.05	1.05	1.49	0.51	1.49	1.49	2.10
CD at 5 %	2.14	2.14	2.14	2.14	3.03	3.03	3.03	3.03	3.03	3.03	4.28	1.47	4.28	4.28	6.06

Note: S_1: Winter season, **S_2**: Summer season, **D_1**: Depth at 5cm, **D2**: Depth at 10cm, **L_1:** Agro-forestry Bengaluru, **L_2**: Bio-fuel park Hassan, **T_1**:*Simarouba glauca,* **T_2**:*Calophyllum inophyllum*